



OPEN ACCESS

EDITED BY

Yuzhen Xu,
Tongji University, China

REVIEWED BY

Shi-Bin Wang,
Guangdong Mental Health
Center, China
Lei Xia,
Chaohu Hospital of Anhui Medical
University, China

*CORRESPONDENCE

Wei Zheng
zhengwei0702@163.com
Ze-Zhi Li
biolpsychiatry@126.com

†These authors have contributed
equally to this work

SPECIALTY SECTION

This article was submitted to
Alzheimer's Disease and Related
Dementias,
a section of the journal
Frontiers in Aging Neuroscience

RECEIVED 05 September 2022

ACCEPTED 10 October 2022

PUBLISHED 24 October 2022

CITATION

Zheng W, Zhang X-Y, Xu R, Huang X,
Zheng Y-J, Huang X-B, Li Z-Z and
Chen H-D (2022) Adjunctive
accelerated repetitive transcranial
magnetic stimulation for older patients
with depression: A systematic review.
Front. Aging Neurosci. 14:1036676.
doi: 10.3389/fnagi.2022.1036676

COPYRIGHT

© 2022 Zheng, Zhang, Xu, Huang,
Zheng, Huang, Li and Chen. This is an
open-access article distributed under
the terms of the [Creative Commons
Attribution License \(CC BY\)](#). The use,
distribution or reproduction in other
forums is permitted, provided the
original author(s) and the copyright
owner(s) are credited and that the
original publication in this journal is
cited, in accordance with accepted
academic practice. No use, distribution
or reproduction is permitted which
does not comply with these terms.

Adjunctive accelerated repetitive transcranial magnetic stimulation for older patients with depression: A systematic review

Wei Zheng^{1*†}, Xin-Yang Zhang¹, Rui Xu¹, Xiong Huang¹,
Ying-Jun Zheng¹, Xing-Bing Huang¹, Ze-Zhi Li^{1*†} and
Huo-Di Chen²

¹The Affiliated Brain Hospital of Guangzhou Medical University, Guangzhou, China, ²Laboratory of Laser Sports Medicine, School of Sports Science, South China Normal University, Guangzhou, China

Objective: We performed this systemic review to investigate the therapeutic potential and safety of adjunctive accelerated repetitive transcranial magnetic stimulation (aTMS) for older patients with depression.

Methods: We included published randomized clinical trials (RCTs) and observational studies targeting adjunctive aTMS for older patients with depression.

Results: Two open-label self-controlled studies ($n = 29$) fulfilled the criteria for inclusion. The included studies reported significant improvements in depressive symptoms from baseline to post-aTMS (all P s < 0.05). One study reported a dropout rate of 10.5% (2/19). Mild headache was the most common adverse reaction.

Conclusion: The currently available evidence from two open-label self-controlled studies indicates that adjunctive aTMS is a safe and effective therapy for older patients with depression.

KEYWORDS

accelerated TMS, depression, systematic review, older patients, response

Introduction

Depression is a leading cause of disability ([World Health Organization, 2017](#)), and occurs in 7% of the elderly population worldwide ([World Health Organization, 2016](#)). A diagnosis of depression in old age is often associated with poorer long-term prognoses, higher recurrence rates, lower quality of life, and a greater likelihood of morbidity and early mortality ([Mitchell and Subramaniam, 2005](#); [Aziz and Steffens, 2013](#)). Up to 1/3 of individuals experiencing major depressive disorder (MDD), particularly in the elderly population, fail to achieve clinical remission after acute pharmacological treatment ([Rush et al., 2006](#)). Because comorbid physical diseases are common, elderly patients with depression are highly likely to experience side effects of medication

(Kok and Reynolds, 2017). Thus, non-pharmacological treatments, such as electroconvulsive therapy (ECT) (Dong et al., 2018; Jiang et al., 2020), transcranial magnetic stimulation (TMS) (Blumberger et al., 2015; Conelea et al., 2017), transcranial direct current stimulation (tDCS) (Kumar et al., 2020; Brooks et al., 2021), vagus nerve stimulation (VNS) (van Rooij et al., 2020), deep brain stimulation (DBS) (McDonald, 2016) and theta-burst stimulation (TBS) (Cristancho et al., 2020), may be reasonable alternatives for older patients with depression.

A type of non-invasive brain stimulation, repetitive transcranial magnetic stimulation (rTMS), was approved by the FDA as a treatment for MDD in 2008 (Holtzheimer et al., 2010). A network meta-analysis of 81 randomized clinical trials (RCTs) found that active rTMS showed a significantly higher clinical response and remission rates than non-active rTMS (Brunoni et al., 2017). A typical course for rTMS involves five days of treatment/week over a period of 3–6 weeks (Holtzheimer et al., 2010). However, this schedule may be inconvenient for patients and can hinder compliance (Frey et al., 2020). Thus, consolidating the treatment (e.g., over 2–3 days) may make it more accessible and could potentially increase compliance.

Accelerated rTMS (aTMS) protocols have been studied as a potential solution for this problem (Sonmez et al., 2019). Recent meta-analyses have found that aTMS protocols may be effective for individuals suffering from depression (Sonmez et al., 2019) and post-stroke depression (PSD) (Frey et al., 2020). A randomized controlled study (RCT) of twice-daily rTMS for the treatment of MDD found that rTMS given twice daily was effective and safe (Loo et al., 2007). Two open-label studies have also reported positive findings for adjunctive aTMS as a therapy in addition to antidepressants for older patients with depression (Dardenne et al., 2018; Desbeaumes Jodoin et al., 2019). For example, Dardenne et al. reported that aTMS was safe and well-tolerated in older patients with MDD (≥ 65 years old) (Dardenne et al., 2018). Similarly, a recent study reported that aTMS protocol (two sessions per day) is a safe and effective treatment for older patients (≥ 60 years old) suffering from treatment-resistant depression (TRD) (Desbeaumes Jodoin et al., 2019).

To date, no systematic review examining the therapeutic role and safety of adjunctive aTMS for older patients with depression has been published. In view of this important gap, we conducted this review to systematically investigate the efficacy and safety of adjunctive aTMS for older patients with depression.

Methods

Search strategy and selection criteria

Two investigators (X-YZ and RX) independently searched electronic databases (including PsycINFO, Cochrane Library, PubMed, EMBASE, Chinese Journal Net, and WanFang)

and manually checked reference lists of the included studies (Dardenne et al., 2018; Desbeaumes Jodoin et al., 2019) and relevant reviews (Mutz et al., 2019; Sonmez et al., 2019) for eligible studies on adjunctive aTMS for older patients with depression. The initial search was completed by two investigators (XYZ and RX) on December 16, 2021, using the following search terms: (accelerated TMS OR accelerated rTMS OR aTMS OR accelerated transcranial magnetic stimulation OR accelerated repetitive transcranial magnetic stimulation) AND (depression OR depressed OR depressive) AND (aged OR elderly OR older adult OR aging).

In line with PRISMA guidelines (Moher et al., 2009), we included studies that fulfilled the following *PICOS* criteria. **Participants:** older patients (≥ 60 years old) suffering from uni- or bi-polar depression, as defined by the respective studies. **Intervention vs. Comparison:** real aTMS with antidepressants vs. antidepressant monotherapy or sham aTMS with antidepressants; aTMS added to antidepressants (observational studies). **Outcomes:** the primary outcome was changed in depressive symptoms as measured by depression scales [i.e., the Montgomery-Asberg Depression Rating Scale (MADRS) (Montgomery and Asberg, 1979; Zhong et al., 2011)]. Key secondary outcomes reported in this systematic review were study-defined response and remission, dropout rate, and adverse events. **Study:** only published RCTs or observational studies (single-group, before-after design) investigating the efficacy and safety of aTMS in combination with antidepressants for older patients with uni- and bi-polar depression were eligible for inclusion. As reported previously (Mutz et al., 2019), TBS included the following three different treatment strategies: intermittent TBS, continuous TBS, or bilateral TBS. Thus, studies with at least two rTMS sessions rather than one TBS session per day were included. Review articles, retrospective studies, and case reports/series were excluded.

Data extraction

Two independent investigators (X-YZ and RX) extracted relevant data from each included study. Any disagreements were resolved through consensus or, if needed, through discussion with the senior author (WZ). Missing data were requested by contacting first and/or corresponding authors and/or searching for the data from other reviews (Sonmez et al., 2019).

Quality assessment

The quality of RCT were independently evaluated by two investigators (X-YZ and RX) using the Cochrane risk of bias (Higgins et al., 2011).

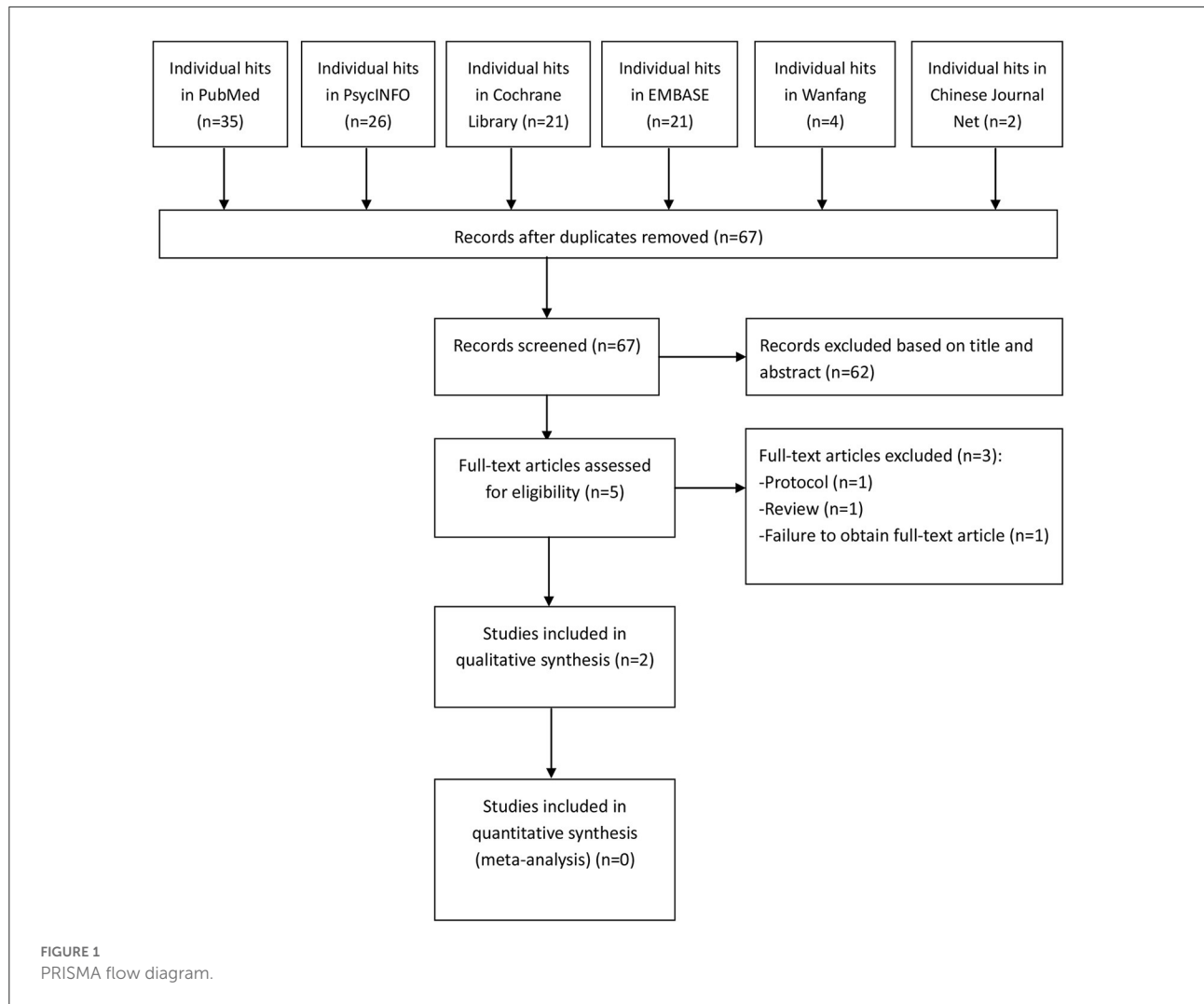


TABLE 1 Summary of characteristics of included studies.

References (country)	N (♂/♀)	Study design	- Diagnosis - Diagnostic criteria	Age: yrs (range)	Medication status	Type site; Frequency (intensity)	Total stimuli (stimuli/session); - Total days (sessions/day, Total sessions)	- Trains/session - Train length - Intertrain
Dardenne et al. (2018) (Belgium)	10 (0/10)	Open-label	- MDD - DSM-IV	73.9 (65–82)	Psychotropic -allowed	HF-rTMS L-DLPFC; 20 Hz (110%)	31200 (1560 pluses); 4 (5, 20)	- 39 s - 2 s - 12 s
Desbeaumes Jodoin et al. (2019) (Canada)	19 (10/9) ^a	Open-label	- TRD (17 unipolar, 2 bipolar) - DSM-5	71.0 (60–89)	Psychotropic -allowed	HF-rTMS L-DLPFC; 20 Hz (110%)	60000–90000 (3000 pluses); 10–15 (2, 20–30)	- 150 s - 5 s - 25 s

^aData were extracted only focusing on older patients (≥60 years old) with depression.

DSM, Diagnostic and Statistical Manual of Mental Disorders; HF, high frequency; L-DLPFC, left dorsolateral prefrontal cortex; MDD, major depressive disorder; N, number of patients; NR, not reported; NOS, newcastle-ottawa scale; rTMS, repetitive transcranial magnetic stimulation; TRD, treatment-resistant depression.

♂ = Male; ♀ = Female.

TABLE 2 The improvement of depressive symptoms after aTMS.

References	Assessment tools	At baseline (mean \pm SD, n)	At end of study (mean \pm SD, n)	<i>P</i> -value
Dardenne et al. (2018)	HDRS scores	22.6 \pm 4.1 (<i>n</i> = 10)	10.6 \pm 7.9 (<i>n</i> = 10) ^a	0.004
	BDI scores	25.9 \pm 7.0 (<i>n</i> = 10)	10.8 \pm 7.1 (<i>n</i> = 10) ^a	0.004
Desbeaumes Jodoin et al. (2019)	MADRS scores	21.7 \pm 9.3 (<i>n</i> = 19)	9.4 \pm 7.6 (<i>n</i> = 19) ^b	<0.001

^aPatients were assessed at post-aTMS.

^bPatients were assessed at seven days after the last aTMS session.

Bolded values are *P* < 0.05.

aTMS, accelerated transcranial magnetic stimulation; BDI, Beck Depression Inventory; HDRS, Hamilton Depression Rating Scale; MADRS, Montgomery-Asberg Depression Rating Scale; n, number of patients.

TABLE 3 Dropout rate and adverse events.

References	Sample size	Dropout rate	Adverse events	
		Total (%)	Events	Total (%)
Observational studies (<i>n</i> = 29)				
Dardenne et al. (2018)	10	0 (0)	Local discomfort	1 (10)
			Mild headache	4 (40)
Desbeaumes Jodoin et al. (2019)	19	2 (10.5)	Headache	3 (15.8)
			Local sensitivity	3 (15.8)
			Fatigue	1 (5.3)

Results

Study selection

As shown in Figure 1, we identified a total of 109 hits in this systematic review. In the end, two open-label self-controlled studies met the inclusion criteria and were included in our qualitative analysis (Dardenne et al., 2018; Desbeaumes Jodoin et al., 2019).

Study characteristics

The characteristics of the two observational studies (Dardenne et al., 2018; Desbeaumes Jodoin et al., 2019), covering 29 older patients with MDD (*n* = 27) or bipolar depression (*n* = 2), are summarized in Table 1. One of the studies (*n* = 10) (Dardenne et al., 2018) was conducted in Belgium; the other (*n* = 19) (Desbeaumes Jodoin et al., 2019) was conducted in Canada.

Assessment of study quality

We did not use the Cochrane risk of bias assessment because no RCTs fulfilled the inclusion criteria.

Depressive symptoms

As shown in Table 2, the two included studies consistently reported significant improvements in depressive symptoms from baseline to post-aTMS (all *P*s < 0.05). In Dardenne et al.'s (2018) study, 40% (4/10) of older patients with MDD showed responses, and 20% (2/10) met the remission criteria. In Desbeaumes Jodoin, Miron and Lespérance (2019) study, 14 out of 19 older patients (73.7%) responded to aTMS, and 63.2% (12/19) met remission criteria.

Dropout rate and adverse events

Dropout rate and adverse events are summarized in Table 3. The dropout rate was 10.5% (2/19) in Desbeaumes Jodoin, Miron and Lespérance (2019) study and 0% (0/10) in Dardenne et al.'s (2018) study. Mild headaches were the most common adverse events, accounting for 40% of side effects (Dardenne et al., 2018).

Discussion

This article is the first systematic review to examine the potential therapeutic role and safety of adjunctive aTMS for older patients (≥ 60 years old) suffering from depression. Only two observational studies (Dardenne et al., 2018; Desbeaumes Jodoin et al., 2019) involving 29 older patients with depression

were included in this systematic review. The two studies (Dardenne et al., 2018; Desbeaumes Jodoin et al., 2019) were published within the last three years, indicating that this is a novel and clinically important topic. This systematic review provides preliminary support for the utility of aTMS for reducing depressive symptoms in older patients with depression. Furthermore, adjunctive rTMS was safe and well-tolerated in elderly depressed patients. However, aTMS may have resulted in higher discomfort rates than standard daily rTMS (Fitzgerald et al., 2018).

According to this systematic review, adjunctive aTMS appears to be effective in treating older patients suffering from depression, although the long-term efficacy was not reported. The rationale for an accelerated approach comes from the idea that repeated application of stimulation within short time intervals could be associated with greater antidepressant effects (Sonmez et al., 2019). A recent review reported that high-frequency (HF) rTMS delivered over the left dorsolateral prefrontal cortex (DLPFC) could reduce suicidal behavior in individuals with the treatment-resistant depression (Godi et al., 2021).

The response rates of HF rTMS tended to range from 20 to 30% (O'Reardon et al., 2007; Avery et al., 2008; George et al., 2010), which was far lower than the response rate to aTMS (73.7%) (Desbeaumes Jodoin et al., 2019). However, a recent RCT, involving 115 outpatients with MDD who randomly received either aTMS or standard daily rTMS, found that aTMS and rTMS had comparable efficacy for treating depression (Fitzgerald et al., 2018). Although this systematic review found that aTMS may be an effective therapy in elderly patients with depression, a variety of parameters have been applied to the two included studies (Dardenne et al., 2018; Desbeaumes Jodoin et al., 2019). For example, the total stimuli of aTMS ranged between 31,200 and 90,000, and the optimal parameters for aTMS remain unclear.

The following limitations must be considered. First, only two open-label self-controlled studies (single-group, before-after design) examining the efficacy and safety of adjunctive aTMS for older patients with depression were included (Dardenne et al., 2018; Desbeaumes Jodoin et al., 2019). Second, the relatively small sample sizes in both studies potentially reduced their power and increased the possibility of type II error. Third, this systematic review on adjunctive aTMS for older patients with depression has not been registered. Fourth, given that the heterogeneity between the studies, a quantitative analysis could not be performed in this study. Finally, some important outcome measures, such as cognitive functioning, were not reported in the included studies.

Conclusions

The current evidence from open-label self-controlled studies, while limited, indicates that adjunctive aTMS is a safe

and effective therapy for older patients with depression. Further RCTs with rigorous methodology need to be performed in order to confirm and extend these findings.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

Author contributions

X-YZ and RX selected studies and extracted the data. WZ reviewed all the data, helped mediate disagreements, and wrote the first draft. All authors contributed to the interpretation of data and approved the final manuscript.

Funding

This study was funded by the the Science and Technology Planning Project of Liwan District of Guangzhou (202004034), National Natural Science Foundation of China (82101609), Scientific Research Project of Guangzhou Bureau of Education (202032762), Science and Technology Program Project of Guangzhou (202102020658), Guangzhou Health Science and Technology Project (20211A011045), Guangzhou science and Technology Project of traditional Chinese Medicine and integrated traditional Chinese and Western medicine (20212A011018), China International Medical Exchange Foundation (Z-2018-35-2002), Guangzhou Clinical Characteristic Technology Project (2019TS67), science and Technology Program Project of Guangzhou (202102020658), and Guangdong Hospital Association (2019ZD06). The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

- Avery, D. H., Isenberg, K. E., Sampson, S. M., Janicak, P. G., Lisanby, S. H., Maixner, D. F., et al. (2008). Transcranial magnetic stimulation in the acute treatment of major depressive disorder: clinical response in an open-label extension trial. *J. Clin. Psychiatry* 69, 441–451. doi: 10.4088/JCP.v69n0315
- Aziz, R., and Steffens, D. C. (2013). What are the causes of late-life depression? *Psychiatr. Clin. North Am.* 36, 497–516. doi: 10.1016/j.psc.2013.08.001
- Blumberger, D. M., Hsu, J. H., and Daskalakis, Z. J. (2015). A Review of brain stimulation treatments for late-life depression. *Curr. Treat Options Psychiatry* 2, 413–421. doi: 10.1007/s40501-015-0059-0
- Brooks, H., Oughli, H. A., Kamel, L., Subramanian, S., Morgan, G., Blumberger, D. M., et al. (2021). Enhancing cognition in older persons with depression or anxiety with a combination of mindfulness-based stress reduction (MBSR) and transcranial direct current stimulation (tDCS): results of a pilot randomized clinical trial. *Mindfulness* 12, 3047–3059. doi: 10.1007/s12671-021-01764-9
- Brunoni, A. R., Chaimani, A., Moffa, A. H., Razza, L. B., Gattaz, W. F., Daskalakis, Z. J., et al. (2017). Repetitive transcranial magnetic stimulation for the acute treatment of major depressive episodes: a systematic review with network meta-analysis. *JAMA Psychiatry* 74, 143–152. doi: 10.1001/jamapsychiatry.2016.3644
- Conelea, C. A., Philip, N. S., Yip, A. G., Barnes, J. L., Niedzwiecki, M. J., Greenberg, B. D., et al. (2017). Transcranial magnetic stimulation for treatment-resistant depression: naturalistic treatment outcomes for younger versus older patients. *J. Affect Disord.* 217, 42–47. doi: 10.1016/j.jad.2017.03.063
- Crastancho, P., Kamel, L., Araque, M., Berger, J., Blumberger, D. M., Miller, J. P., et al. (2020). iTBS to relieve depression and executive dysfunction in older adults: an open label study. *Am. J. Geriatr. Psychiatry* 28, 1195–1199. doi: 10.1016/j.jagp.2020.03.001
- Dardenne, A., Baeken, C., Crunelle, C. L., Bervoets, C., Matthys, F., and Herremans, S. C. (2018). Accelerated HF-rTMS in the elderly depressed: a feasibility study. *Brain Stimul.* 11, 247–248. doi: 10.1016/j.brs.2017.10.018
- Desbeaumes Jodoin, V., Miron, J. P., and Lespérance, P. (2019). Safety and efficacy of accelerated repetitive transcranial magnetic stimulation protocol in elderly depressed unipolar and bipolar patients. *Am. J. Geriatr. Psychiatry* 27, 548–558. doi: 10.1016/j.jagp.2018.10.019
- Dong, M., Zhu, X. M., Zheng, W., Li, X. H., Ng, C. H., Ungvari, G. S., et al. (2018). Electroconvulsive therapy for older adult patients with major depressive disorder: a systematic review of randomized controlled trials. *Psychogeriatrics* 18, 468–475. doi: 10.1111/psyg.12359
- Fitzgerald, P. B., Hoy, K. E., Elliot, D., Susan McQueen, R. N., Wambeck, L. E., and Daskalakis, Z. J. (2018). Accelerated repetitive transcranial magnetic stimulation in the treatment of depression. *Neuropsychopharmacology* 43, 1565–1572. doi: 10.1038/s41386-018-0009-9
- Frey, J., Najib, U., Lilly, C., and Adcock, A. (2020). Novel TMS for stroke and depression (NoTSAD): accelerated repetitive transcranial magnetic stimulation as a safe and effective treatment for post-stroke depression. *Front. Neurol.* 11:788. doi: 10.3389/fneur.2020.00788
- George, M. S., Lisanby, S. H., Avery, D., McDonald, W. M., Durkalski, V., Pavlicova, M., et al. (2010). Daily left prefrontal transcranial magnetic stimulation therapy for major depressive disorder: a sham-controlled randomized trial. *Arch. Gen. Psychiatry* 67, 507–516. doi: 10.1001/archgenpsychiatry.2010.46
- Godi, S. M., Spoorthy, M. S., Purushotham, A., and Tikka, S. K. (2021). Repetitive transcranial magnetic stimulation and its role in suicidality—a systematic review. *Asian J. Psychiatr.* 63:102755. doi: 10.1016/j.ajp.2021.102755
- Higgins, J. P., Altman, D. G., Gotzsche, P. C., Juni, P., Moher, D., Oxman, A. D., et al. (2011). The cochrane collaboration's tool for assessing risk of bias in randomised trials. *BMJ* 343:d5928. doi: 10.1136/bmj.d5928
- Holtzheimer, P. E. 3rd, McDonald, W. M., Muffit, M., Kelley, M. E., Quinn, S., Corso, G., and Epstein, C. M. (2010). Accelerated repetitive transcranial magnetic stimulation for treatment-resistant depression. *Depress. Anxiety* 27, 960–963. doi: 10.1002/da.20731
- Jiang, X., Xie, Q., Liu, L. Z., Zhong, B. L., Si, L., and Fan, F. (2020). Efficacy and safety of modified electroconvulsive therapy for the refractory depression in older patients. *Asia Pac. Psychiatry* 12:e12411. doi: 10.1111/appy.12411
- Kok, R. M., and Reynolds, C. F. 3rd (2017). Management of depression in older adults: a review. *JAMA* 317, 2114–2122. doi: 10.1001/jama.2017.5706
- Kumar, S., Batist, J., Ghazala, Z., Zomorodi, R. M., Brooks, H., Goodman, M., et al. (2020). Effects of bilateral transcranial direct current stimulation on working memory and global cognition in older patients with remitted major depression: a pilot randomized clinical trial. *Int. J. Geriatr. Psychiatry* 35, 1233–1242. doi: 10.1002/gps.5361
- Loo, C. K., Mitchell, P. B., Mcfarquhar, T. F., Malhi, G. S., and Sachdev, P. S. (2007). A sham-controlled trial of the efficacy and safety of twice-daily rTMS in major depression. *Psychol. Med.* 37, 341–349. doi: 10.1017/S0033291706009597
- McDonald, W. M. (2016). Neuromodulation treatments for geriatric mood and cognitive disorders. *Am. J. Geriatr. Psychiatry* 24, 1130–1141. doi: 10.1016/j.jagp.2016.08.014
- Mitchell, A. J., and Subramaniam, H. (2005). Prognosis of depression in old age compared to middle age: a systematic review of comparative studies. *Am. J. Psychiatry* 162, 1588–1601. doi: 10.1176/appi.ajp.162.9.1588
- Moher, D., Liberati, A., Tetzlaff, J., and Altman, D. G. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *BMJ* 339:b2535. doi: 10.1136/bmj.b2535
- Montgomery, S. A., and Åsberg, M. (1979). A new depression scale designed to be sensitive to change. *Br. J. Psychiatry* 134, 382–389. doi: 10.1192/bjp.134.4.382
- Mutz, J., Vipulanathan, V., Carter, B., Hurlmann, R., Fu, C. H. Y., and Young, A. H. (2019). Comparative efficacy and acceptability of non-surgical brain stimulation for the acute treatment of major depressive episodes in adults: systematic review and network meta-analysis. *BMJ* 364:l1079. doi: 10.1136/bmj.l1079
- O'Reardon, J. P., Solvason, H. B., Janicak, P. G., Sampson, S., Isenberg, K. E., Nahas, Z., et al. (2007). Efficacy and safety of transcranial magnetic stimulation in the acute treatment of major depression: a multisite randomized controlled trial. *Biol. Psychiatry* 62, 1208–1216. doi: 10.1016/j.biopsych.2007.01.018
- Rush, A. J., Trivedi, M. H., Wisniewski, S. R., Nierenberg, A. A., Stewart, J. W., Warden, D., et al. (2006). Acute and longer-term outcomes in depressed outpatients requiring one or several treatment steps: a STAR*D report. *Am. J. Psychiatry* 163, 1905–1917. doi: 10.1176/ajp.2006.163.11.1905
- Sonmez, A. I., Camsari, D. D., Nandakumar, A. L., Voort, J. L. V., Kung, S., Lewis, C. P., et al. (2019). Accelerated TMS for depression: a systematic review and meta-analysis. *Psychiatry Res.* 273, 770–781. doi: 10.1016/j.psychres.2018.12.041
- van Rooij, S. J. H., Riva-Posse, P., and McDonald, W. M. (2020). The efficacy and safety of neuromodulation treatments in late-life depression. *Curr. Treat Options Psychiatry* 7, 337–348. doi: 10.1007/s40501-020-00216-w
- World Health Organization (2016). *Mental Health and Older Adults*. Geneva: World Health Organization. Available online at: <http://www.who.int/mediacentre/factsheets/fs381/en/>
- World Health Organization (2017). *Depression and Other Common Mental Disorders: Global Health Estimates*. Geneva: World Health Organization.
- Zhong, B. L., Wang, Y., Chen, H. H., and Wang, X. H. (2011). Reliability, validity and sensitivity of Montgomery-Åsberg Depression Rating Scale for patients with current major depressive disorder [in Chinese]. *Chin. J. Behav. Med. Brain Sci.* 20, 85–87. doi: 10.3760/cma.j.issn.1674-6554.2011.01.032